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(54) Hybrid drive system for motor vehicle, having means for inhibiting electricity generating drive mode

(57) Hybrid motor vehicle drive system (10) including an electric motor (14) operated by an electric energy generated by an electric generator (14) and stored in a storage (36), an engine (12), and a controller (28) for controlling the engine and electric generator to operate in an electricity generating drive mode when a predetermined condition is satisfied, such that the engine is operated so as to provide an output greater than a required power (PL) to drive the motor vehicle, so that the vehicle is driven by the engine with the required power while the electric generator is operated by the engine with a surplus power to charge the storage, and wherein the controller (28) includes a special control device (S4) operated in the event of a failure of the electric generator (14), for inhibiting the selection of the electricity generating drive mode and selecting an engine drive mode to operate the engine (12) for driving the motor vehicle with the required power, even when the predetermined condition is satisfied.

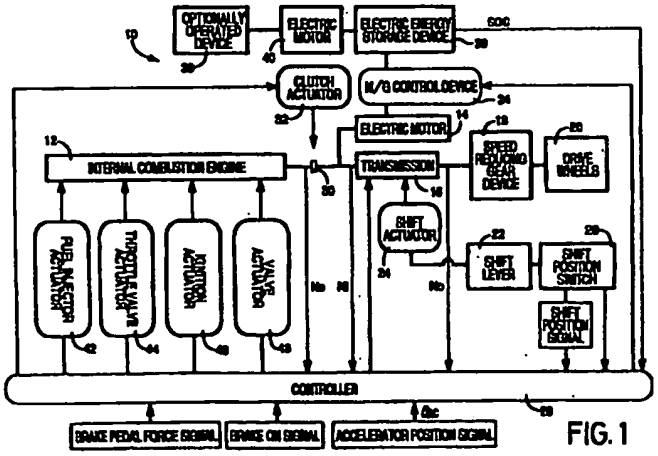

FIG. 1

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motor may be adapted to also function as the electric generator. In this case, the special control means of the controller is activated at least when the electric motor fails to normally function as the electric generator (but is normally operated by the electric energy stored in the electric energy storage device).

The special control means of the controller may be adapted to be activated to select the engine drive mode for driving the vehicle with the required power, at least when the electricity generating drive mode would be selected with the predetermined condition being satisfied if the electric generator was normal. Described in detail, the hybrid drive system having the engine drive mode and the electricity generating drive mode may have other drive modes such as a motor drive mode in which only the electric motor is operated to drive the vehicle, and an engine-motor drive mode in which the engine and the electric motor are both operated to drive the vehicle. The engine drive mode is selected when the vehicle running load is relatively high, and the motor drive mode is selected when the vehicle running load is relatively high. The engine•motor drive mode is selected when the vehicle running load is considerably high. In this case, the special control means may be activated in the event of a failure of the electric generator, so as to replace at least the electricity generating drive mode with the engine drive mode. In other words, the special control means need not be activated when the engine drive mode, motor drive mode or engine•motor drive mode is selected by the controller. However, the special control means is desirably adapted to be activated when the motor drive mode or engine•motor drive mode is selected, as well as when the electricity generating drive mode is selected, in the case where the electric motor also functions as the electric generator. In this case, the failure of the electric generator may influence the operations of the hybrid drive system in the motor drive mode and the engine•motor drive mode as well as the operation in the electricity generating drive mode.

The controller may further include means for determining whether the predetermined condition for selecting the electricity generating drive mode is satisfied or not. This means may be adapted to determine whether the predetermined condition is satisfied or not whether an amount of the electric energy stored in the electric energy storage device is smaller than a predetermined lower limit.

The controller may further include means for determining whether the electric generator fails to normally function due to a failure of the electric generator per se, and may further include means for determining whether the electric generator fails to normally function due to a failure of a motor/generator control device which controls the electric motor and the electric generator.

BRIEF DESCRIPTION OF THE DRAWINGS

The above and optional objects, features, advantages and technical and industrial significance of this invention will be better understood by reading the following detailed description of a presently preferred embodiment of the invention, when considered in connection with the accompanying drawings, in which:

Fig. 1 is a block diagram illustrating a hybrid drive system for a motor vehicle, which is constructed according to one embodiment of this invention;

Fig. 2 is a flow chart for explaining a basic routine executed by the hybrid drive system of Fig. 1;

Fig. 3 is a flow chart showing in detail a normal control routine in step S3 of the basic routine of Fig. 2, which is executed when the electric motor of the system is normal;

Fig. 4 is a flow chart showing in detail a special control routine in step S4 of the basic routine of Fig. 2, which is executed in the event of a failure of the electric motor; and

Fig. 5 is a graph for explaining threshold values B and C used in the normal control routine of Fig. 3.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring first to the block diagram of Fig. 1, there is diagrammatically illustrated a hybrid drive system 10 for driving a motor vehicle. In Fig. 1, thick solid lines indicate mechanical connection of components, while thin solid lines indicate electrical connection of components. The hybrid drive system 10 includes two drive power sources, namely, an internal combustion engine 12 such as a gasoline engine operated by combustion of a fuel, and an electric motor 14 operated by an electric energy. Power of the engine 12 and the power of the electric motor 14 are simultaneously or selectively transmitted to a transmission 16, and transferred to drive wheels 20 of the vehicle through a speed reducing gear device and a differential gear device. The transmission 16 includes a forward-reverse switching mechanism and a shift mechanism. The switching mechanism has three positions: forward position (FWD) for running the vehicle in the forward direction; reverse position (REV) for running the vehicle in the rearward direction; and neutral position (N). The shift mechanism has a plurality of forward-driving positions having respective different speed ratios, which are selectively established when the forward-reverse switching mechanism is placed in the forward position (FWD). The transmission 16 is shifted by a shift actuator 24 so that the transmission 16 is placed in one of the neutral and reverse positions and the forward-driving positions, depending upon the currently selected position of a shift lever 22. Described in detail, the currently selected position of the shift lever 22 is detected by a shift position switch 26. The shift actuator 24 is controlled by a controller 28, according to a SHIFT POSITION signal received from the shift position switch 26 indicative of the currently selected position of the shift lever 22. The engine 12

energy storage device 36 is equal to or larger than a predetermined lower limit A. If an affirmative decision (YES) is obtained in step S3-2, the control flow goes to step S3-3 and the following steps. If a negative decision (NO) is obtained in step S3-2, the control flow goes to step S3-8 to implement an electricity generating drive mode sub-routine. The lower limit A is the minimum amount of the electric energy required to operate the electric motor 14 for driving the motor vehicle in an engine-motor drive mode or a motor drive mode in which the electric motor 14 is operated as the drive power source, as described below with respect to steps S3-5 and S3-7. The lower limit A is determined depending upon the charging and discharging efficiencies of the electric energy storage device 35. For example, the lower limit A is in the neighborhood of 70% of the full capacity of the device 36. In the electricity generating drive mode sub-routine in step S3-8, the hybrid drive system 10 is operated in an electricity generating drive mode in which the engine 12 is operated so as to provide an output which is larger than the calculated required power PL, and the electric motor 14 is operated as the electric generator with the surplus power which is a difference between the engine output and the required power PL, so that the electric energy generated by the electric generator 14 is stored in the electric energy storage device 36. Described more specifically, the controller 28 controls the M/G control device 34 such that the surplus power of the engine is consumed by the electric generator 14 so that the calculated required power PL is transmitted from the engine 12 to the transmission 16 for driving the vehicle. The torque T_E and speed Ne of the engine 12 and the electric generator 14 are controlled depending upon the currently selected position of the transmission 16 and the expected power loss of the system. It will be understood that a portion of the controller assigned to implement step S3-8 constitutes means for controlling the hybrid drive system 10 in the electricity generating drive mode. This mode is selected when the negative decision (NO) is obtained in step S3-2, namely, when the amount of electric energy SOC currently stored in the electric energy storage device 36 is smaller than the predetermined lower limit A.

Step S3-3 implemented when the affirmative decision (YES) is obtained in step S3-2 is provided to determine whether the required power PL is larger than a predetermined first threshold value B. If an affirmative decision (YES) is obtained in step S3-3, the control flow goes to step S3-4 to determine whether the required power PL is larger than a predetermined second threshold value C which is larger than the first threshold value B. If the negative decision (NO) is obtained in step S3-3, that is, if the required power PL is equal to or smaller than the first threshold value B, it means that the motor vehicle is currently running under a relatively low load. In this case, the control flow goes to step S3-7 to implement a motor drive mode sub-routine. If an affirmative decision (YES) is obtained in step S3-3 while a negative decision (NO) is obtained in step S3-4, that is, if the required power PL is larger than the first threshold value B and is equal to or smaller than the second threshold value C, it means that the vehicle is currently running under a medium load. In this case, the control flow goes to step S3-6 to implement an engine drive mode sub-routine. If an affirmative decision (YES) is obtained in step S3-4, that is, the required power PL is larger than the second threshold value C, it means that the vehicle is running under a relatively high load. In this case, the control flow goes to step S3-5 to implement an engine • motor drive mode sub-routine.

In the motor drive mode sub-routine in step S3-7, the hybrid drive system 10 is operated in the motor drive mode indicated above with respect to the lower limit A. In the motor drive mode, only the electric motor 14 is operated as the drive power source for running the vehicle. In the engine drive mode sub-routine in step S3-6, the hybrid drive system 10 is operated in an engine drive mode in which only the engine 12 is operated as the drive power source for running the vehicle. In the engine • motor drive sub-routine in step S3-5, the hybrid drive system 10 is operated in the engine • motor drive mode indicated above with respect to the lower limit A. In the engine • motor drive mode, the engine 12 and the electric motor 14 are both operated as the drive power sources for running the vehicle. In these drive modes in steps S3-5, S3-6 and S3-7, the outputs of the engine 12 and electric motor 14 are controlled depending upon the currently selected position of the transmission 16 and the expected power loss. In the engine drive mode in step S3-6, the electric motor 14 is held in a non-load condition. In the motor drive mode in step S3-7, the clutch 30 is placed in the released state so that the output of the electric motor 14 is transmitted to only the transmission 16.

Each of the first and second threshold values B and C may be determined depending upon the current running condition of the vehicle, for instance, on the basis of the vehicle drive torque and the vehicle speed V and according to a predetermined relationship as shown in Fig. 5 by way of example. This relationship is provided for each of the forward-drive positions of the transmission 16. When the running condition of the vehicle as represented by the drive torque and speed V is in an area on a lower load side of a curve representative of the first threshold B, namely, on the side nearer to the origin "0", it means that the required power PL in equal to or smaller than the first threshold B. In this case, step S3-7 is implemented to execute the motor drive mode sub-routine. When the running condition is in an area between the curve representative of the first threshold B and a curve representative of the second threshold C, it means that the required power PL is larger than the first threshold B and is equal to or smaller than the second threshold C. In this case, step S3-6 is implemented to execute the engine drive mode sub-routine. When the running condition is in an area on a higher load side of the curve representative of the second threshold C, it

wheels 20.

It is to be understood that the present invention may be embodied with various other changes, modifications and improvements, which may occur to those skilled in the art.

Claims

1. A hybrid drive system (10) for a motor vehicle, including (a) an electric generator (14) for generating an energy, (b) an electric energy storage device (36) for storing the electric energy generated by said electric generator, (c) an electric motor (14) operated as a first drive power source by the electric energy stored in said electric energy storage device, (d) an engine (12) operated as a second drive power source by combustion of a fuel, and (e) a controller (28) for controlling said engine and said electric generator to operate in an electricity generating drive mode when a predetermined condition is satisfied, such that said engine is operated so as to provide an output greater thin a required power (PL) necessary for driving the motor vehicle, so that the motor vehicle is driven by said engine with said required power while said electric generator is operated by said engine with a surplus power to charge said electric energy storage device, said surplus power being equal to said output minus said required power, said hybrid drive system being characterised in that:

   said controller (28) includes special control means (S4) operated in the event of a failure of said electric generator (14), for inhibiting the selection of said electricity generating drive mode and selecting an engine drive mode to operate said engine (12) for driving the motor vehicle with said required power, even when said predetermined condition for selecting said electricity generating drive mode is satisfied.

2. A hybrid drive system according to claim 1, wherein said electric motor (14) also functions as said electric generator.

3. A hybrid drive system according to claim 1 or 2, wherein said controller (28) further includes means (S3-2) for determining whether said predetermined condition for selecting said electricity generating drive mode is satisfied or not.

4. A hybrid drive system according to claim 3, wherein said means for determining whether said predetermined condition is satisfied or not comprises means for determining whether an amount of the electric energy stored in said electric energy storage device (36) is smaller than a predetermined lower limit.

5. A hybrid drive system according to any one of claims 1-4, wherein said controller (18) further includes means (S2) for determining whether said electric generator (14) fails to normally function due to a failure of said electric generator per se.

6. A hybrid drive system according to any one of claims 1-5, further comprising a motor/generator control device (34) for controlling said electric generator (14) and said electric motor (14), and wherein said controller (18) further includes means (S2) for determining whether said electric generator (14) fails to normally function due to a failure of said motor/generator control device.

7. A hybrid drive system according to any one of claims 1-6, wherein said controller (28) selects one of said engine drive mode, a motor drive mode in which only said electric motor (14) in operated to drive the motor vehicle, and an engine • motor drive mode in which said engine (12) and said electric motor are both operated to drive the motor vehicle, depending upon a current running condition of the motor vehicle, if said predetermined condition for selecting said electricity generating drive mode is not satisfied.

8. A hybrid drive system according to claim 7, wherein said controller (28) selects one of said engine drive mode, said motor drive mode and said engine • motor drive mode, depending upon a current running load of the motor vehicle.

9. A hybrid drive system according to claim 8, wherein said controller (28) includes means (S3-3, S3-4 and S3-5) for determining said current running load of the motor vehicle, depending upon a drive torque and a running speed of the motor vehicle.

FIG. 2

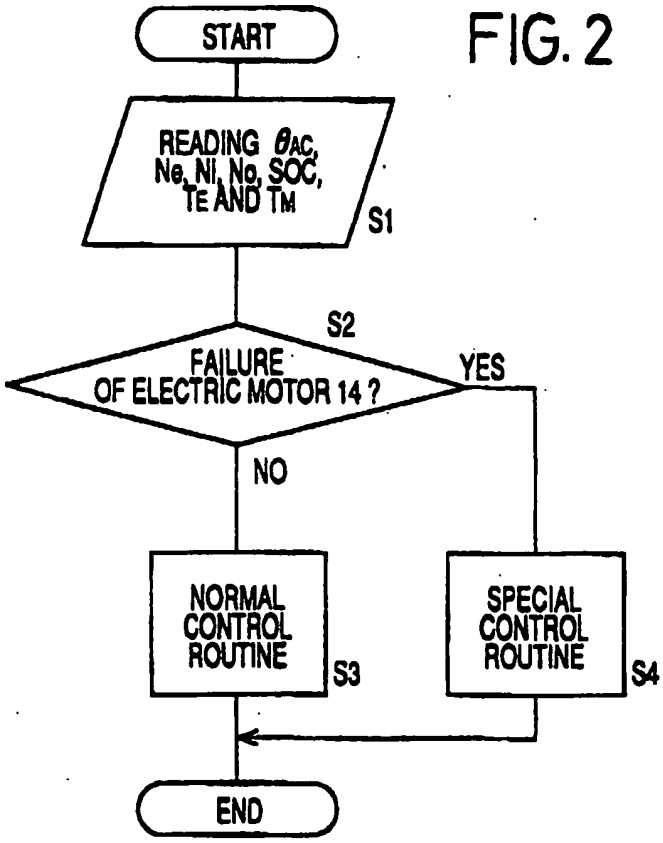

FIG. 4

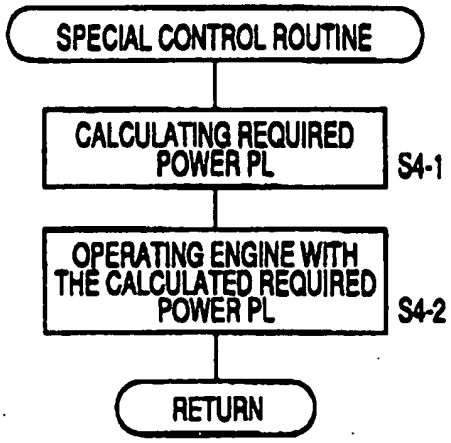

FIG. 5